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A STRATEGY FOR MEASURING THE ROLLING RESISTANCE OF MINE HAULROADS

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A STRATEGY FOR MEASURING THE ROLLING RESISTANCE OF MINE HAULROADS

by

Richard J. Kolada* and Nigel Stuart**

ABSTRACT

The rolling resistance of mine haulage roads can have a large economic impact on the cost of material transportation. Current methods for determining mine site rolling resistances involves the use of two trucks; one to tow the other. To use trucks for this purpose is very expensive and mine operators are therefore discouraged from using this method. This paper describes an alternative method of measuring rolling resistances using a trailer that can be towed by a small off-highway vehicle and proposes how the measurements should be taken and used.

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UNE STRAGÉGIE POUR MESURER LA RÉSISTANCE AU ROULEMENT DES VOIES DE TRANSPORT DANS LES MINES

par

Richard J. Kolada* et Nigel Stuart**

RÉSUMÉ

La résistance au roulement des voies de transport dans les mines peut avoir d'importantes répercussions économiques sur les frais de transport des matériaux. Les méthodes actuelles pour déterminer la résistance au roulement d'un chantier d'exploitation nécessitent l'utilisation de deux camions, l'un remorquant l'autre. L'utilisation de camions à cette fin est très coûteuse, et les exploitants de mines sont donc moins portés à utiliser cette méthode. Le présent rapport décrit une autre méthode pour mesurer la résistance au roulement au moyen d'une remorque qui peut être tirée par un petit véhicule tous-terrains et propose des façons de prendre les mesures et de les utiliser.

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INTRODUCTION

The detrimental effects of rolling resistance on the production of mine truck haulage fleets may be classified into one of two cases.

(1) What we may call "acute" rolling resistance problems that cause an obvious and significant loss of production. This situation may, for example occur on steep gradients during a spring melt. This can result in a reduced payload, in urgent remedial actions to divert water and to repair the road and may result in vehicles gettin bogged down.

(2) "Pervasive" rolling resistance problems can be said to occur particularly on long hauls where the result is a poor fleet productivity throughout the year. This problem is not as evident as (1). However, a mine with less than optimally maintained roads will pay through a variety of truck operations costs. In addition to productivity costs (tons per truck hour) fuel and maintenance costs are effected.

A meaningful study of rolling resistance has the following components:

(1) The ability to measure it. We must obtain data from a wide variety of mines under different climatic conditions.

(2) The ability to interpret rolling resistance in terms of truck productivity and economics.

(3) To understand the mechanisms of rolling resistance and how rolling resistance correlates with soil and tire parameters: A theoretical understanding of this subject is well developed.

(4) To document the remedial actions available to a mine operator (road surface improvement, tire-pressure setting, truck size etc.) in terms of costs and benefits by means of a theoretical understanding and impirical knowledge.

Of the above (1) is being urgently pursued by the authors, (2) is well covered in terms of productivity simulation by models such as those of the N.R.C. systems laboratory, but is yet to be approached in terms of the economics of rolling resistance (the latter is of interest to the authors), (3) is a well developed science but it is thought that there is scope for impirical work to correlate rolling resistance with easily made soil

mechanics tests; indeed such data should routinely be collected with rolling resistance measurements. Remedial actions are well known (4), but it is hoped to be able to better quantify their likely effects.

A STANDARD METHOD OF MEASURING ROLLING RESISTANCE

Two primary considerations for the design of a standard method to measure rolling resistance are, (a) the measurements should be performed quickly to avoid delays to the haulage fleet, and (b) the measurements should be representative of the entire length of haulroad that is under examination.

The apparatus that CANMET has chosen to measure rolling resistance consists of a two wheeled trailer with a load cell in the tow bar with which to measure the force required to tow the trailer, (see figure 1). This trailer is currently under construction by Davis Engineering Ltd. and is expected to be operational in the spring of 1987. The trailer will be equipped with water tanks so that ballast can be added to the trailer at the mine site. An automatic data acquisition system will record data from a variety of sensors. Initially the parameters that will be measured will include:-

(a) the angle of the trailer and hence the grade of the road,
(b) ambient air temperature,
(c) towbar force,
(d) trailer velocity,
(e) displacement of the suspension system relative to the trailer bed.

The trailer should fulfill the objectives of providing a rapid method of measurement and will be able to provide continuous measurements over the entire length of haulroad that is under examination. Since the trailer can conduct measurements at the same speed as haulage trucks usually operate, these measurements should not hinder their production.

FIELD INVESTIGATIONS

There are many parameters related to the study of mine haulage road rolling resistances. Unfortunately it is unlikely that there will be sufficient resources to investigate them all concurrently. However, this paper is intended to present an overall long term strategy and therefore all

the parameters that will eventually be examined are discussed.

CORRELATIONS OF ROLLING RESISTANCE MEASUREMENTS WITH VEHICLE TYPE

There are many factors that affect the rolling resistance experienced by a vehicle that are unique to that type of vehicle. For example, rolling resistance is obviously dependent on the depth of tire penetration. This in return is dependent on the gross vehicle weight and how this weight is distributed between front and back axle. Indeed, the vehicle may have more than two axles and more than two tires on each axle. Tire penetration also depends on tire pressure and the type of tire used. To ensure that the measurements taken by the trailer will correlate as close as possible to those experienced by the trucks, the trialer will use ballast so that the depth of tire penetration is the same as that of the trucks. To do this, measurements of tire rut depth of the trucks and trailer will be required.

The fact that different types of trucks will experience different rolling resistances over the same stretch of road, introduces the question of how to correlate the trailer measurements of rolling resistance to those experienced by different types of trucks. This may be achieved by direct measurement; i.e. measure the force required to tow one truck with another. The trailer can then be used over the same stretch of road and a direct correlation can be made between the results of towing the truck and by using the trailer. It is also possible to obtain direct rolling resistance measurements from a single self driven truck equipped with sensors connected to a data gathering system. Several types of truck data gathering systems are available that can be connected to a wide variety of sensors.

Once the rolling resistances measured by the trailer are correlated to the rolling resistance actually experienced by the types of trucks used at a mine, then the trailer may be used to investigate rolling resistances of the entire mine haulage road system. This information can then be used in computer haulage modelling programs to provide accurate predictions of how a particular haulage fleet would perform on modified haulage routes. For example, an estimate can be made of how improved haulroads would affect production. Also, an economic analysis would reveal the optimum expenditure on improving haulroads with respect to the gains from an improved haulage fleet productivity. There are many other factors that affect the haulage

operating costs of a mine that can be investigated once a correlation between trailer and directly measured truck rolling resistances has been made. A summary of these investigations are described below.

TIRE PERFORMANCE

The rolling resistance of a truck over the same road conditions can be directly measured while using two different sets of tires. Then, by using the trailer to measure the rolling resistances of the entire haulage route it will be possible to predict the economic impact of using one set of tires in favour of the other. Different tire pressures also give different rolling resistances and the effect of tire pressure may be investigated in the same manner as for different types of tires. Since the cost of tires are a major proportion of haulage operating costs these types of investigations are of considerable importance.

TRUCK DERATION

As a truck gets older its performance decreases. This is known as deration and it is a very important factor for analysing truck productivity. By measuring how long it takes a truck to accelerate to the maximum permitted velocity, over a section of haulroad of known rolling resistance, it is possible to back calculate the engine performance of the truck. If this is done at periodic intervals the deration of engine performance with age can be measured. A catalogue of this information for various truck types would be valuable when deciding what type of truck to purchase for any given task. Obviously a truck that derates quickly in comparison to similar trucks would not be selected if they were of similar price.

CORRELATION WITH HANDHELD GEOTECHNICAL INSTRUMENTS

There are a number of handheld geotechnical instruments available for testing the strength of haulroads, such as penetrometers and vane shear testers. These instruments give spot measurements and are easy and quick to use. There should be a correlation between the measurements taken by these instruments and rolling resistance. They have the disadvantage that they are likely to be more time consuming and possibly less accurate than measurements taken by the trailer. However, they are inexpensive in comparison to the trailer and are readily available (there is only one trailer at present). These instruments also require much less experience to use. Consequently

they may be valuable to mine operators who wish to survey the conditions of their haulroads on a regular basis. There are many potential advantages to such a program. Mine operators will be able to identify road sections that require the most maintenance and will be able to examine how road conditions vary due to climatic changes and traffic volumes. They will also be able to compare the effectiveness of road construction and maintenance techniques. Before such a program can be undertaken, it will be necessary to validate the usefulness of these instruments. this will be done in conjunction with the validation of the trailer.

THE EFFECT OF VEHICLE VELOCITY ON ROLLING RESISTANCE

The rolling resistance experienced by a vehicle over any particular length of road depends on the velocity of the vehicle. By using the trailer which can be towed at various velocities, with a range similar to those attained by haulage trucks, the phenomenon of varying rolling resistances at different velocities may be investigated.

CONCLUSIONS

The ability to directly measure haulroad rolling resistances will provide the opportunity to embark on a wide ranging program of research that is of major consequence to the operating costs of surface mines. The strategy of research described in this report is expected to place the task of mine haulage design and operation on a much more rigid scientific basis allowing a much greater range of alternative to be considered. This will hopefully lead to greater savings in haulage operating costs and to improved mine production.

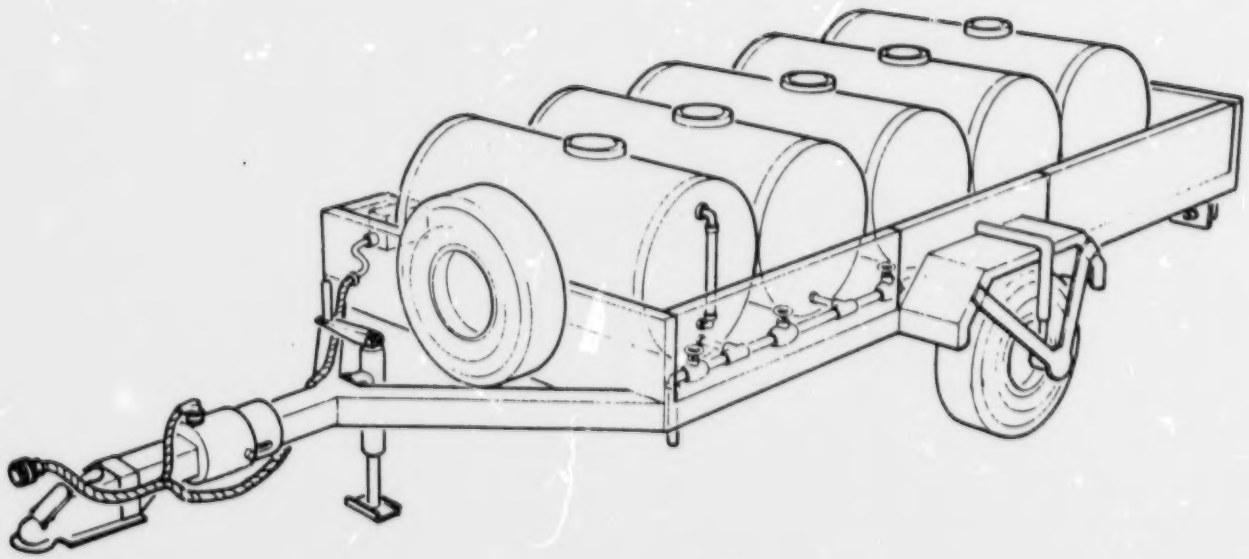

Figure 1 Rolling Resistance Trailer